6. PROCESS ALTERNATIVES

The following discussion of solidification/stabilization processes and definitions has been excerpted from a current EPA published document:[8]

"The term 'solidification/stabilization' refers to a general category of processes that are used to treat a wide variety of wastes, including solids and liquids. Solidification/stabilization (S/S) is an established technology that has been used for almost 20 years to treat a variety of wastes at Superfund sites throughout the country. Historically, S/S has been one of the top five source control treatment technologies used at Superfund remedial sites."

Solidification and stabilization are each distinct technologies, as described below (see Reference 8):

- Solidification – refers to processes that encapsulate a waste to form a solid material and to restrict contaminant migration by decreasing the surface area exposed to leaching and/or by coating the waste with low-permeability materials. Solidification can be accomplished by a chemical reaction between a waste and binding (solidifying) reagents or by mechanical processes. Solidification of fine waste particles is referred to a microencapsulation, while solidification of a large block or container of waste is referred to as macroencapsulation.

- Stabilization – refers to processes that involve chemical reactions that reduce the leachability of a waste. Stabilization chemically immobilizes hazardous materials or reduces their solubility through a chemical reaction. The physical nature of the waste may not be changed by this process.

For S/S applications at Superfund sites, the regulatory definition of stabilization under the Resource Conservation Recovery Act (RCRA) may be relevant to a project. Under the LDR program stabilization may be used to render a RCRA hazardous waste (defined under 40 CFR part 260) non-hazardous prior to disposal. RCRA defines stabilization (40 CFR 268.42) as "[a process that] involves the use of the following reagents (or waste reagents): (1) Portland cement; or (2) lime/pozzolans (e.g., fly ash and cement kiln dust) – this does not preclude the addition of reagents (e.g., iron salts, silicates, and clays) designed to enhance the set/cure time and/or compressive strength, or to overall reduce the leachability of the metal or inorganic.

In addition, S/S processes can involve the use of very high temperatures (usually greater than 1,500 °F) to vitrify wastes, forming glass-like waste products (see Reference 8).

The scope of this project is treatment of hazardous wastes to ICDF acceptance standards (LDRs) as identified previously in Section 2 and the TFR document with ARARs by the most feasible, economical, and safe method. This project will involve stabilization and not necessarily solidification. The terms stabilization, fixation, or chemical fixation, have been used interchangeably in the past and in the literature. The terms generally denote chemical reactions or interactions of contaminants to fix or immobilize the contaminants to a degree so as to render them non-hazardous.

Conner[10] provides discussion of the various categories of fixation (chemical fixation or stabilization) mechanisms relevant to treatment of metals which are generally considered economical and feasible. Actual methods may include one or more categories and include:

- pH control

- Redox potential control
- Precipitation
    - Hydroxide/oxide
    - Sulfide
    - Silicate
    - Carbonate
    - Phosphate
    - Coprecipitation
    - Inorganic complexation
    - Organic complexation
- Bonding to an insoluble substrate
- Sorption and chemisorption
- Passivation
- Ion exchange
- Diadochy (selective transition metal cation uptake function of anionic clays)
- Encapsulation
    - Microencapsulation
    - Macroencapsulation
    - Embedment
- Extraction.

The waste inventory effort has identified the majority of the waste as having a soil-like waste matrix contaminated with cadmium, chromium, lead, mercury, and silver. The EPA considered the following four processes at a meeting in 1995 (see Reference 9) and evaluated the merits of each technology:

- Phoenix ash technology
- Portland cement (PC) stabilization
- Sulfur polymer encapsulation
- Polymer encapsulation.

The Portland cement based process had the highest rating for all of the evaluation criteria used for coarse sands and gravels considered in the EPA study. The PC-based stabilization concept is very generic and includes the utilization of reagents mixed with the waste to promote fixation or stabilization. This type of process was selected for implementation in the SSSTF based on the project goals, EPA reference evaluation, and engineering review of problem definition, data collection, data analysis, review of past experience and lessons learned, and review of issues and commercial practices.

The process may be implemented by a variety of systems and components but generally include the functions of size reduction if necessary, mixing and blending at some energy level to attain an adequate or defined level of homogeneity or consistency, and material conveyance. This covers a wide range of actual equipment. Various combinations of additives and reagents may be utilized within the PC process including, but not limited to, PC/flyash, PC/lime, PC/flyash/blast furnace slag both air and water cooled, PC/flyash/blast furnace slag/clay, etc. Actual combinations and recipe formulations are determined during treatability testing of the various soil types and the contaminants to be stabilized.

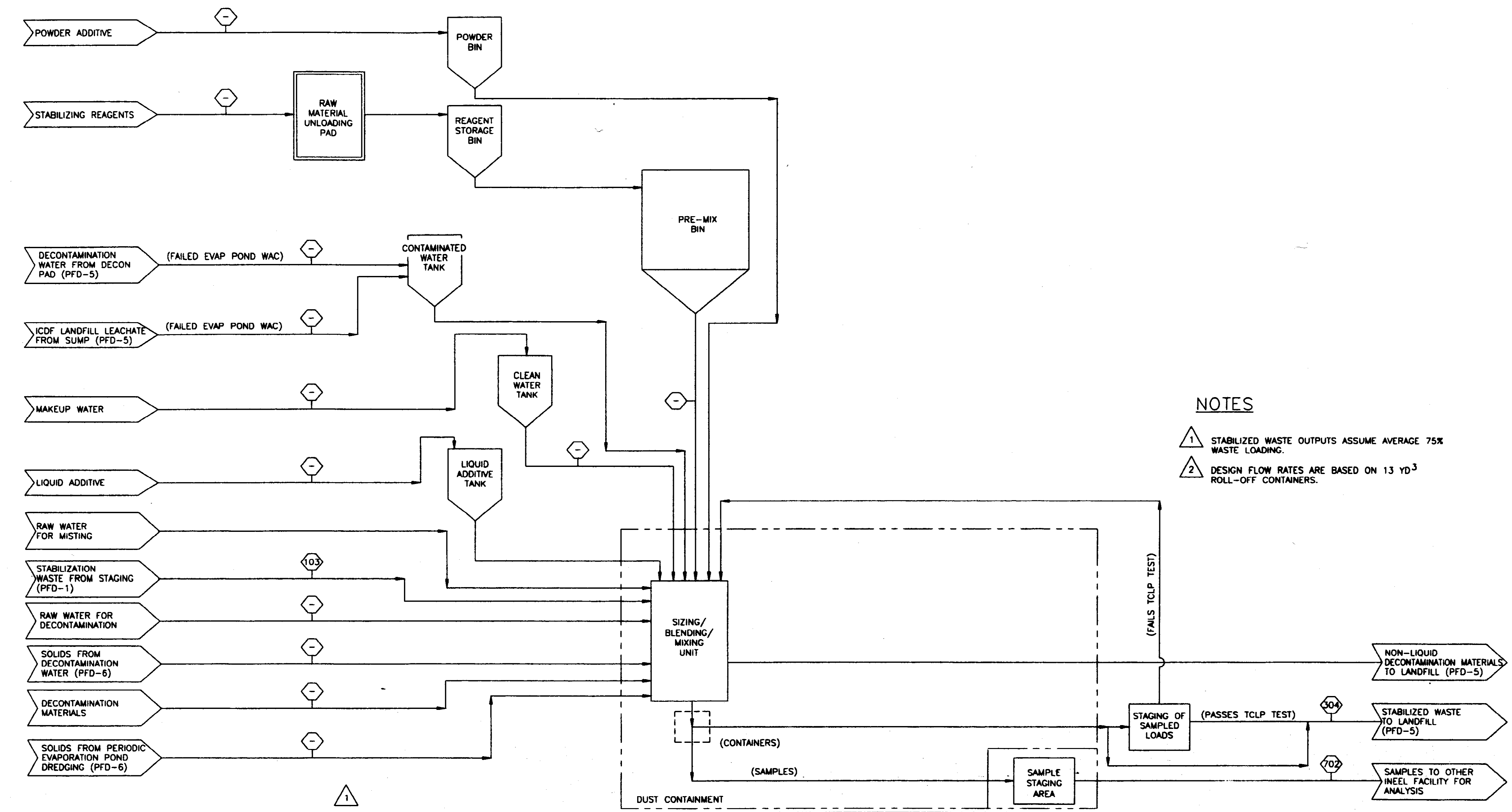
Solidification of wastes is not included in the scope of this project for the majority of this waste although some degree of solidification may be included within and as a by-product of the scope of stabilization depending on actual recipe formulations and the physical structure of the waste. Likewise, the use of high temperatures to stabilize/solidify wastes into glass-like products through vitrification is not included in the scope of this project.

In addition, treatment of smaller amounts of special case or larger size materials may involve solidification treatment using binding (solidifying) reagents or macroencapsulation methods. One macroencapsulation method utilized commercially is to place large debris-like material into a heavy wall poly container, fill it with concrete, and seal the container prior to placing into the landfill.

7. PROCESS DESCRIPTION

Figure 7-1 provides a high-level process flow diagram for the SSSTF stabilization process. Various combinations of additives and reagents may be utilized within the process including, but not limited to, PC/flyash, PC/lime, PC/flyash/blast furnace slag both air and water cooled, PC/flyash/blast furnace slag/clay, etc. Actual combinations and recipe formulations are determined during treatability testing of the various soil types and the contaminants to be stabilized. The process includes the following major equipment components or facility areas:

- Raw material unloading station
- Bulk reagent bins (PC, blast furnace slag, flyash, etc.)
- Pre-mix bin
- Dry and liquid additive bins or tanks
- Waste water tank(s) and piping
- Waste container unloading station
- Blender/mixer unit
- Container fill station



PROCESS STREAM	103	105	304 △1	702	-	-	-	-											
DESCRIPTION	STABILIZATION WASTE		STABILIZED WASTE	SAMPLES															
FLOW RATE, MAX (YD^3/YR)	11,110		14,813																
FLOW RATE, DESIGN (CONTAINERS/HR) △2	1.0		1.0																
FLOW RATE, DESIGN (GPH)	-		-	-															
VOLUME, TOT (YD^3)	35,765		47,687																
VOLUME, TOT (GAL)	-		-	-															

Figure 7-1. Stabilization process flow diagram.

- Stabilized material containers
- Container staging station
- Product sample station
- Product sample transfer station
- Process confinement providing for dust suppression system(s), and a physical structure utilized in conjunction with filtered ventilation air
- Decontamination and washdown systems
- Process interfaces for waste form packaging/loading
- Associated process material transfer equipment.

8. STABILIZED MIXTURE FORMULATION

Research on other systems provides potential indication of performance of SSSTF stabilization. Table 8-1 provides a list of the metals from the CWID database, the maximum concentration, the site where the maximum occurs, a reference recipe used for other material at a reference concentration (see Conner), and the TCLP/LDR limits. The reference recipe is for the reference feed concentration most closely matching the CWID concentration. The leachate concentration was the one obtained for the Chemical Fixation and Stabilization (CFS) stabilization type shown in Table 8-1 at that feed concentration.

Table 8-1. CFS Performance.

			Reference Recipe					Regulatory Limits	
RCRA Metal	Max. CWID Conc., mg/kg	Site/WAG	Stabilization Type	MR[a]	WL (%)	Feed Conc.[b] (mg/L)	Leachate, (mg/L)	TCLP (mg/L)	LDR (mg/L)
Arsenic	40	ARA-12, -25/5	PC, Kiln Dust, and Lime/Flyash	0.05-0.10	91-95	36	<0.010	5	5
Barium	4,100	Borax-1/10	Cement Kiln Dust	0.5	67	2,270	0.57	100	2.1
Cadmium	120	Borax-1/10	PC, Kiln Dust, and Lime/Flyash	0.05-0.10	91-95	481	3.29, 1.743, 0.052	1	0.11
Chromium	940	Borax-1/10	PC, Kiln Dust, and Lime/Flyash	0.05-0.10	91-95	1,370	0.043, 0.032, 0.073	5	0.6
Lead	3,340	Borax-1/10	Cement Kiln Dust	0.5	67	2,740	0.78	5	0.75
Mercury	440	CFA-04/4	PC, Kiln Dust, and Lime/Flyash	0.05-0.10	91-95	3.8	0.001, <0.001, 0.002	0.2	0.02
Selenium	20	ARA-12/5	PC, Kiln Dust, and Lime/Flyash	0.05-0.10	91-95	<5.0	<0.01	1	5.7
Silver	300	ARA-12/5	PC, Kiln Dust, and Lime/Flyash	0.05-0.10	91-95	39	<0.003	5	0.14

a. Reagent to waste mass ratio. To convert to waste loading (%) $WL = \frac{100}{1+MR}$

b. The concentration used was that closest to the waste analyzed via TCLP from Tables 4-20 through 4-35 in Reference 10.

The following issues are relevant for the stabilization treatment process.

- **Arsenic**. Arsenic (As) is not a metal but is commonly classified as a heavy metal under environmental regulations as it is only problematic at high concentrations. All of the processes examined were capable of fixating As at concentrations within an order of magnitude of the waste concentrations.

- **Cadmium**. Cadmium (Cd) forms stable complexes with ammonia, cyanide, and halides. Cd will not precipitate in alkaline solution if cyanide is present. Cd is very sensitive to pH and will leach out significantly if the pH < 7. However, the TCLP does not overcome the alkalinity of most CFS systems except at low MRs. Cd is not bound into the silica matrix like lead and chrome. In some systems, Cd may be sorbed or fixed by cation exchange using the following:

Kaolin Clay	0.05 mg/g
Flyash	0.22 mg/g
Sawdust	0.11 mg/g

- **Chromium** (Cr). Suspected respeciation of chrome to silicate matrix. Therefore, a silicate system (e.g., PC and/or flyash) is likely required (see remarks about Cd).

- **Lead** (Pb). Suspected respeciation of Pb to silicate matrix. Therefore, a silicate system (e.g., PC and/or flyash) is likely required (see remarks about Cd).

- **Mercury** (Hg). Hg is unlikely to be fixed in a simple CFS system and requires an additive. Sulfide anion is normally used for this at about 20% excess. Since sulfides also react with other metals forming insoluble compounds, it is preferred to treat the mercury first. While this is not possible for this waste, the treatability study needs to determine how much additional sulfide is required for Pb, Cu, and other metals.

- **Barium (Ba).** Barium is an alkaline earth metal with chemical behavior similar to that of calcium (also an alkaline earth metal). Barium is easily stabilized in Portand cement systems and is presumably due to its ability to substitute for calcium and take part in the cement hydration reactions.

- **Selenium (Se).** Selenium is readily stabilized in Portland cement systems. In addition, no significant levels of selenium are expected at any of the targeted waste sites.

- **Silver (Ag).** Silver is readily precipitated by chloride and as such, natural attenuation by chloride in the soil would reduce its leachability. In addition, sulfides will also precipitate silver. Only in the presence of chemical chelates or complexing agents would silver be expected to leach from cement systems.

A preliminary review of waste that requires stabilization for metals that may contain some organics was performed using CWID derived compounds and concentrations. While the organic compounds do not require any treatment due to low concentrations, they might interfere with the fixation/stabilization of the metals by interaction with the matrix. Table 8-2 includes the organic compounds found in the CWID database, the maximum concentration, and the site where the maximum occurs. Based on best engineering judgement, the concentrations are too low to interfere with fixation in a CFS system.

Table 8-2. Organic Concentrations In CFS Systems.

Organic Compound	Max. CWID Conc., mg/kg	Site/WAG
Carbon Disulfide	1	WRRTF-1/1
Isobutyl Alcohol	0.3	BORAX-1/10
Benzene	5	BORAX-1/10
Toluene	98	BORAX-1/10
Pyridine	34	ARA-25
Chlorobenzene	1	BORAX-1/10, WRRTF-1/1
1,2-Dichlorobenzene	17	BORAX-1/10
Perchloroethylene	1	WRRTF-1/1
Methylene Chloride	1	WRRTF-1/1
Trichloroethylene	1	WRRTF-1/1
1,1,1-Trichloroethane	1	WRRTF-1/1
1,1,2-Trichloroethane	1	WRRTF-1/1
Trichlorofluoromethane	0.06	BORAX-1/10
Carbon Tetrachloride	1	WRRTF-1/1

However, some of the compounds may retard curing rates, interfere with cement reactions, and interfere with physical properties of the matrix. If any of the compounds are determined to interfere with fixation during treatability studies (e.g., TCLP), additional additives may be required. Some of these potential additives include organo-clays (natural clays modified with organic compounds), activated carbon/charcoal, and surfactants.

For SSSTF stabilization requirements, a mix with high waste loading may be sufficient to fix the hazardous metals and meet the ICDF landfill WAC. As an example, the CFA04 soil contains mercury contamination concentrations of approximately 440 mg/kg. Blending in a stabilization agent such as CaS to the matrix in quantities sufficient (20% excess) to ensure the stabilization of the contaminant results in increases still in the milligram per kilogram range (10^6). Adding in additional reagents and water for dust control may result in a very small net increase in volume.

For some waste streams, a waste product with a maximally loaded matrix of the order of 90 % may be sufficient to meet the ICDF WAC. For other highly contaminated or problematic waste steams, waste loadings may be on the order of 20%-30% and require the addition of significant reagent material in order to meet acceptance criteria. Actual waste loadings for the majority of waste streams will most likely vary between approximately 50 to 95% depending on the requirements of the mixture recipe in accordance with ICDF waste acceptance criteria, and will be determined on case-by-case basis. A product with high waste loading would more typically resemble the original matrix material (damp soil) in appearance.

The identified total volume of waste to be stabilized is approximately 35,765 yd^3. At a waste loading of 50%, the total volume of product is 71,530 yd^3.

35,765 yd^3/0.50 = 71,530 yd^3 of final mixture

At a waste loading of 95%, the total volume of product is 37,647 yd^3.

At a nominal 75% waste loading, the total volume of product is 47,687 yd^3.

9. STABILIZATION PROCESS CONSIDERATIONS

Depending on the contaminant that may require stabilization and the recipe required to stabilize the waste to meet waste acceptance criteria, the stabilization process may produce a waste form which physically may vary in color and texture. Variations include stabilized waste forms which closely resemble the original matrix material, more closely resemble a solidified grout or concrete type product, or resemble a product between the two such as a crumbly, damp, different-colored product. The variations depend on the contaminant to be stabilized, the recipe utilized, the quantity and type of reagents required for stabilization, the required moisture content, and the waste acceptance criteria.

Considerations for stabilized waste mixtures include:

- Rocks may be an issue; large rocks may jam in-line mixers or other close tolerance machinery.
- The product mixture should produce no excess water and should be visually checked for excess water.
- A Portland cement-based mixture by itself may not pass TCLP test criteria
  - Use blast furnace slag as a dry additive powder to aid in binding contaminants; blast furnace slag comes from steel mills and contains some sulfides, which tend to bind or tie up RCRA contaminants (D codes)
  - Use flyash (Class F) from coal-fired plants. Flyash powder (Class F) does not adsorb water; it resembles tiny glass beads and assists in self-leveling aspects of the mix
  - Use other additives as necessary according to recipe to bind or fix contaminants.
- Water for reactions comes from the moisture content of the soil if the moisture is releasable plus makeup water.
- Dust loading (excess) in soil will absorb water instead of the cement, therefore need to know the amounts of very fine particulate.
- Product testing after sampling to validate the WAC may be an issue for staging and storage. The logistics for TCLP testing may demand significant holding areas and laboratory facilities.
- Soil characterization may only need to be generic but should include testing for moisture content.
- Salt and organic constituents in the soil may have detrimental effects on the reactions for fixation of contaminants.
- Use a recommended maximum storage time frame of 3 months for raw material bin loading, longer terms cause hydration of raw materials and setup resulting in clogging problems.
- The desired quality assurance (QA) approach is to perform front end QA by certifying the process and operational envelope, characterizing the waste, selecting the process and recipe,

and operating and documenting the process and recipe to validate the end product. In-process QA and product QA may then be minimal to ensure processing quality and operational issues.

- The recipes do not need to necessarily maximize waste loading since landfill volume is not a significant issue.

- Lower waste loading increases the processing envelope but also increases the total product volume.

- The time required for the stabilization chemical reactions to complete and the product to cure may be an important consideration for sampling, staging, storage, and transport scenarios.

- TCLP testing is time consuming and requires sample preparation, extraction, and analysis. Estimates of 36-48 hr per sample may dictate significant laboratory capacity and support personnel if the required throughput is high.

10. STABILIZATION TREATMENT PROCESS IMPLEMENTATION

Stabilization was selected as the generic treatment process for use at the SSSTF to treat waste to meet the ICDF landfill WAC. A decision analysis evaluation was conducted to evaluate the stabilization treatment process systems available. This decision analysis evaluation is presented in detail in Appendix C and describes the method for selecting the stabilization process that would best meet the designated requirements and evaluation criteria set forth in the evaluation. The evaluation was performed by personnel with a variety of backgrounds including project management, engineering, regulatory compliance, quality, and radiological and industrial safety.

The decision analysis evaluation was performed on a generic system and component level and can be considered a qualitative evaluation. The analysis followed the format as specified in the DecisionPlus™ software that was used to conduct the evaluation/selection process.

Four design alternatives were evaluated to determine the best approach for stabilization. The recommended alternative was selected for use in the SSSTF 30% design package. The decision analysis evaluation was performed following the steps indicated:

1. Define the project mission

2. Define the system functions

3. Develop the system requirements

4. Define the design alternatives

5. Follow the decision-making process through selecting an alternative.

10.1 Alternative Descriptions

Four systems are have been considered for evaluation which meet the above requirements and minimum criteria. The decision analysis evaluation as presented in Appendix C of these systems highlights issues relevant to the implementation of the SSSTF stabilization process capability. For the purposes of the evaluation, the assumption was made that all four alternatives will have some type of primary dust suppression enclosure, which will be an environmental enclosure only. These systems are described as System Alternatives 1, 2, 3, and 4 below. For each alternative, the design intent in order to meet confinement criteria is to provide a facility interface at the area of transport unloading. This interface will provide control of ventilation air and confinement pressure.

System Alternative 1: Pug Mill System

The pug mill system is a continuous multi-functional system comprising multiple components with each component functionally specialized. Components include:

- In-Feed Roll-On/Roll-Off – Although the soil is assumed to not contain any material greater than 5 in., it will still be screened prior to being discharged into the mixing system.
- Screen –The waste from the roll-off would be discharged onto a screen. Large material not passing through the screen would be directed into another container to be treated as debris. The screen may need to vibrate to segregate material.
- Bin – The material that passed through the screen would then be discharged into the staging bin prior to mixing. Soil will be continuously discharged from the staging bin into the pug mill.
- Mixing Unit – The pug mill is a continuous feed system that will receive waste and reagents at specified rates and mixed using paddles that rotate inside the pug mill.
- Discharge Unit – The pug mill will discharge into the roll-on / roll-off container on the waiting truck. When the truck is full the treated soil discharging from the pug mill will be sent to a surge bin until a new truck and roll-on/roll-off container can be moved in to collect the treated soil.
- Container Interface.
- Output Interface.

A schematic of the pug mill system is provided in Appendix C, Attachment 1, Alternative 1 - Pug Mill System.

System Alternative 2: Cement/concrete Mixer

The cement/concrete mixer system is similar to the pug mill except that it is a batch system with no interior moving parts. The paddles are affixed to the interior of the mixer and the entire mixer rotates. The components of the cement/concrete mixer system include:

- In-Feed Roll-On/Roll-Off – Although the soil is assumed to not contain any material greater than 5 in., it will still be screened prior to being discharged into the mixing system.

- Screen –The waste from the roll-off would be discharged onto a screen. Large material not passing through the screen would be directed into another container to be treated as debris. The screen may need to vibrate to segregate material.

- Bin – The material that passes through the screen would then be split into two or more bins and treated as separate batches

- Gate – Gates will be located on each bin to discharge a batch into the mixer with the reagents. Multiple batches will be required for each roll-on/roll-off transport.

- Rotary Cement/concrete Mixer – This type of mixer has paddles that are fixed to the interior of the mixing drum. The drum is rotated using gears on the outside that are easily maintainable. There are no moving parts inside the drum.

- Out-Feed – After a batch has been sufficiently mixed, the drum will be rotated and the treated soil will be dumped into a waiting roll-on/roll-off container.

A schematic of the cement/concrete mixer system is provided in Appendix C, Attachment 1, Alternative 2 – Cement/concrete Mixer.

System Alternative 3: Komar Shredder-Mixer

The Komar Shredder-Mixer is a multi-functional system with custom-built equipment capable of performing size reduction, material conveyance, and mixing/blending within one basic unit (e.g., an auger type shredder/blender type system).

- In-Feed Roll-On/Roll-Off – The soil is assumed to not contain any material greater than 5 in., it will be directly discharged into a split staging bin.

- Bin – The soil will be split into two or more bins and treated as separate batches.

- Gate – Gates will be located on each bin to discharge each batch into the process hopper with the reagents.

- Process Hopper – The process hopper receives the soil and reagents and is located on top of the mixer-shredder.

- Komar Mixer-Shredder – This type of mixer is a very powerful dual auger system that will mix and shred most materials.

- Out-Feed – As the soil and reagents are mixed and shredded, the treated soil will be directly discharged into a waiting roll-on/roll-off container.

A schematic of the Komar shredder-mixer is provided in Appendix C, Attachment 1, Alternative 3 – Komar Shredder-Mixer.

System Alternative 4: Mixing Basin

The mixing basin system is a custom designed facility structure combined with commercial material handling equipment for segregation, mixing, and loading. This will be accomplished in the basin with the articulated arm equipped with certain end effectors consisting of a backhoe bucket, a loading bucket, hydraulic jaws or others as may be required.

- In-Feed Roll-On/Roll-Off – The soil is assumed to not contain any material greater than 5 in., it will be directly discharged into the mixing basin.
- Steel-Lined Basin – The mixing basin will be large enough to accommodate approximately 26 yd^3 of waste and will be lined with steel plating.
- Reagent Additives – The proper volume of reagents will be added in the mixing basin via conveyors or chutes or pipes.
- Mister – A mister will be used to keep dust levels at acceptable levels during the mixing operation by keeping the soil moist.
- Backhoe (Hydraulic Articulated Arm) – A skilled operator will conduct the mixing of the soil and reagents using a hydraulic articulated arm.
- Interface on Outlet – After the soil has been treated it will be loaded directly into empty roll-on/roll-off containers using the hydraulic articulated arm.

A schematic of the mixing basin is provided in Appendix C, Attachment 1, Alternative 4 – Mixing Basin.

10.2 Implementation Results and Considerations

Following the input of the decision analysis data into the DecisionPlus™ software program, Alternative #4, mixing basins, received the highest score and is the recommendation for implementation of the stabilization process in the 30% design. The scoring results with highlighted basis considerations are shown on the decision analysis diagram in Appendix C, Figure C-1 and were based on group discussion with concensus conclusions. Appendix C, Figure C-2 illustrates the relative ranking of the four different alternatives with the Mixing Basins scoring only slightly higher than the Concrete Mixer followed by the Komar Shredder-Mixer and the Pug Mill. Prior to commencing 90% design, it is suggested that confirmation of possible mitigating issues be investigated to assure or confirm the results of this evaluation. There are some factors that clearly require additional research before the alternative selected moves into final design stages. Those factors or mitigating issues should include thorough review of operational radiological hazards for the wastes planned for treatment, formal cost estimate comparisons between the alternatives, detailed investigation into throughput capabilities for each alternative, and a review of operational limitations for each alternative. If it is apparent that the confirmatory investigations contradict the results of this evaluation, a new evaluation should be held with potential title design re-scoping efforts to follow.

11. THROUGHPUT SIZING CALCULATIONS

11.1 Assumptions

The following assumptions apply:

- 35,765 yd^3 total volume of non-liquid waste to be stabilized
- Identified waste scheduling results in peak waste receipts for stabilization of 11,110 yd^3 per year
- The facility is sized for peak identified throughput rates
- Waste stream volume is primarily INEEL-derived soils
- Waste form product waste loading varies from 50% to 90% with a nominal loading of 75%
- The stabilized mixture results in a product which physically resembles the original matrix material
- The majority of waste is in a soil matrix
- The majority of waste is received in roll-on/roll-off containers with a waste volume of 13 yd^3
- A roll-on roll-off (20 yd^3) container with a nominal 13 yd^3 initial loading can accept the full treated waste volume (nominally 14-18 yd^3)
- 7-year operating time frame
- Assume soil and mixture specific gravity equals 2.3
- Transport from SSSTF to ICDF via standard truck
- 4-day work weeks at 10 hr/work day single shift operation
- 6 productive hours per 10-hr shift (60% efficiency, programmatic assumption)
- 9 month, 150 productive days/year (900 productive hours, programmatic assumption)
- Size process for peak loading using one line with waste loadings of 50 to 90%
- The chosen implementation method is the mixing basin approach based on the decision evaluation (Section 10 and Appendix C).
- Assume same 13 yd^3 roll-on/roll-off containers are used for loading and transport to the ICDF
- Plant process equipment shall be capable of handling a 4 × 4 × 8 ft box.

11.2 Calculations and Basis

Peak receipt waste input:

11,110 yd^3/yr max receipts

11,110 $yd^3/yr/150$ day/yr = 74 yd^3/day

74 yd^3/day / 13 $yd^3/container$ = 5.7 containers per day input (use 6)

74 $yd^3/day/6hr/day$ = 12.3 yd^3/hr

Size a basin to accept 2 container loads. (e.g., 13 yd^3 x 2 = 26 yd^3 plus additional freeboard for reagents. This will allow flexibility to batch one or two container loads).

Based on EDF 1547 (see Reference 5) operating scenarios time and motion study – one basin is adequate to meet the peak process rate of 11,110 yd^3/yr waste receipts on one shift.

Size basin for 35-40 yd^3 ($9 \times 15 \times 8$ ft = 40 yd^3) to allow for adequate room for mixing

Waste inputs to the treatment process equal 6 containers per day at the 13 $yd^3/container$.

Waste outputs equal:

Input / waste loading = output (nominal)

Waste loading range 50-90% with 75% as base design case.

The stabilized mixture will be placed into lined 13 yd^3 containers at the time of mixing and blending. Once in the container, confinement will be maintained until placement into the landfill. Therefore, minimal staging and storage is required after processing. Table 11-1 summarizes the process scenario, batch size, and output based on waste loading. Each assumes a packaged product and transport using standard 80,000 GVW transport tractor-trailers.

Loaded output container:

Using 20 yd^3 roll-on/roll-off containers, check the weight limit for a fully loaded container:

Use specific gravity = 2.3

Table 11-1. Process throughput summary.

	Input Batch Size	Output					
		50 % W.L.[a]		75 % W.L.		90 % W.L.	
Process Scenario	yd^3	yd^3	Containers	yd^3	Containers	yd^3	Containers
6 containers/day @ 13 $yd^3/container$ @ 1 container/batch	13	26	2	17.3	1	14.4	1
6 containers/day @ 13 $yd^3/container$ @ 2 container/batch	26	52	3	34.6	2	28.9	2

a. W.L. = waste loading

$20\ yd^3 \times 27\ ft^3/yd^3 \times 62.4\ lb/ft^3 \times 2.3 = 77{,}500$ lb for maximum loaded truck

$17\ yd^3 \times 27\ ft^3/yd^3 \times 62.4\ lb/ft^3 \times 2.3 = 67{,}300$ lb for nominally loaded truck.

The total transport weight would be an issue for over the road transport. However, for transport from the SSSTF to the ICDF, all transport routes will be internal to the complex.

11.3 Radiation and Exposure Control

A preliminary review of radiation control issues has been performed for the stabilization treatment process for the SSSTF 30% design. The results of this review are as follows.

Within the SSSTF facility the area that has the most radiation risk is within the stabilization building. The waste streams that have been identified to be processed through the stabilization building were analyzed and include CFA-04, Borax-1, ARA-12, ARA-25, WRRTF, and CPP-92. Each specific radionuclide identified was listed. Then the highest specific activity in all of the waste streams for each identified radionuclide was determined. This list then comprises all identified radionuclides and the corresponding highest specific activity and forms a fictitious/new composite waste stream used in bounding calculations for radiation control issues. These radionuclides were then analyzed individually for radiation dose to a worker. The design criteria limit is 500 mrem per year per worker from combined internal and external doses. To envelope the external radiation dose a bounding model was analyzed. This consisted of a cuboid volume of soil the same dimensions as a roll-on/roll-off container (22 × 8 × 5 ft). Next, for each radionuclide, the significant radioactive emission (photon) and corresponding energy (MeV) was listed. Cs-137 and Co-60 were the selected candidate radionuclides from the fictitious composite waste stream. In the model, a worker was placed 30 cm from the soil. The INEEL Radiation Control Manual requires this distance for determining whole body dose. The resultant exposure was less than 10 mrem external radiation in an hour of exposure. This bounds a worker standing next to a roll-on/roll-off container for 50 hours. With standard controls required by the INEEL Radiation Control Manual, the SSSTF 30% design can meet the radiation control issue of external radiation dose. See Appendix B for details of the calculations.

To envelope the internal radiation dose, the bounding model consisted of an activity where a fraction of the soil would become airborne. This activity could be the dumping of soil into a mixing pit within the stabilizing building. DOE-HDBK-3010-94[11] suggests the fraction of soil that becomes airborne is the conservative value of 4E-5 (non-dust suppressed).[11] This value results in an internal radiation dose of 10 rem in one hour exposed to Pu-238 with highest activity (0.3 nCi/g) in the fictitious/composite waste stream. This is the worst internal dose case for the waste streams analyzed.

Then this value is multiplied by the assumed factor [1E-3] that reduces the airborne dust loading contingent upon a fully functional dust suppression system, as required by the 30% SSSTF design. The factor [1E-3] is an assumption for the preliminary design for the stabilization treatment process and will be required to be validated during Title II design efforts. In this model, a worker stands in the cloud of dust for one hour. For the fictitious composite waste stream (dust suppressed), the internal dose is 10 mrem for the hour the worker is standing in the dust cloud. The details of the analysis are in Appendix B. This bounds a worker standing in the dust cloud for 50 hours. With standard controls required by the INEEL Radiation Control Manual, the SSSTF 30% design can meet the radiation control issue of internal radiation dose contingent upon a fully functional dust suppression system, as required by the 30% SSSTF design. This analysis demonstrates that containment, ventilation system, and water sprays are required around the high dust generation areas (e.g., mixing/blending areas). Primary radiation control is the water sprays. Secondary, and only for defense-in-depth, are the facility structure and ventilation. If the water spray system fails, the operation must be immediately shutdown. The details will be in the 90% design, but it is stated here to emphasize that this design does not depend on confinement (containment) structure and ventilation as primary radiation control.

Because external and internal radiation dose is low, ALARA is not a concern for the purposes of the 30% design, but should be considered in the 90% design. Appendix B provides the Radiological Control Design Review sheets.

Because of radiation control issues, the SSSTF stabilization treatment area will have to have controlled access. Sub-areas will need to be designated as Radiation Areas, Contamination Areas, High Contamination Areas, and/or Airborne Radioactivity Areas. These will include not only the stabilization building but also waste storage areas, waste holding queues, and the radiological decontamination area. A bounding loose surface contamination analysis was performed. Details are in Appendix B. Within the stabilization building, the dumping, mixing, load-out area will probably need to be designated as High Contamination and Airborne Radioactivity Areas depending on the waste stream being processed. With a fully functional dust suppression system, as required by the 30% SSSTF design and good housekeeping, the area outside the dumping, mixing, load-out area but still within the stabilization building may only need to be defined as a Contamination Area, depending on the waste stream being processed. The details will be included in the 90% design.

A constant air monitor (CAM) and a Personnel Contamination Monitor are the instruments that will be needed for the stabilization building. Radiological control technicians using portable radiation control survey instruments will be needed to assess the adequacy of radiation contamination controls. Also a proportional counter will be needed to analyze the radioactivity on smears taken during routine surveys. A portable air sampler will also be needed for spot sampling.

Final characterization in conjunction with shipping criteria may require an incoming radiation survey. Samples of the effluent water will need to be assessed for amount of radioactivity. Major sources of this water will be the pit area of the stabilizing pits and the radioactivity decontamination facility.

12. RESULTS SUMMARY

Based on the identified waste scheduling input rate, and the nominal equipment sizes required to handle the stabilization throughput, the following preliminary results are summarized as the base case for the stabilization treatment process:

- Based on the conclusion of the decision analysis and evaluation, implement the Alternative #4, mixing basins, approach for design and construction of the stabilization system..

- The stabilization process will produce a low compressive strength stabilized mixture. The physical appearance will resemble the original matrix material. Waste loading will nominally be in the range of 50-90%. Some waste streams may require lower waste loadings or may be satisfactory with higher loadings, but the majority will be on the order of 75% waste loading.

- The total volume of material delivered to the SSSTF for stabilization will be approximately 35,765 yd^3, and will result in a net volume increase equal to 1/waste loading or approximately 47,687 yd^3 (50,000 yd^3) delivered to the ICDF.

- The total identified maximum input waste volume receipts are 11,110 yd^3/year delivered to the stabilization process in any one year.
- Based on operating days per year (150) and on operating efficiency (6 productive hours/10 hour shift), maximum waste receipts will be 6 roll-on/roll-off containers loaded with 13 yd^3 of soil.
- The process will be sized to handle 100% peak receipts.
- The stabilized mixture will be placed in lined containers (20 yd^3) for confinement and transfer to the landfill.
- Based on 75% waste loading, the transfer of stabilized soil mixture will result in loading 6 roll-on/roll-off for transport to the ICDF.
- The process will include a fully functional dust suppression system as the first line of defense in controlling radioactive airborne contamination and worker exposure.
- The process will be housed within a confinement area as a defense in-depth approach for controlling dust and radiological loose surface and airborne contamination control. Confinement is used in the radiological control sense and includes the physical facility structure in combination with a working filtered ventilation system to maintain control of airflow and pressures from potentially less contaminated areas to more contaminated areas. All waste streams identified for stabilization have concentrations of transuranic radionuclides less than 10 nCi/g.
- The confinement will be ventilated with air, run under slightly negative air pressure, and the exhaust air filtered through pre-filters and final high-efficiency particulate air (HEPA) filters.
- The confinement should incorporate interface connection zones for input of SSSTF accepted waste packages and bulk material. These zones will include means for controlling the input of material into the confinement area.
- Prior to commencing 90% design it is suggested that confirmation of possible mitigating issues be investigated to assure or confirm the results of the system implementation decision evaluation. There are some factors that clearly require additional research before the alternative selected moves into final design stages. Those factors or mitigating issues should include thorough review of operational radiological hazards for the wastes planned for treatment, formal cost estimate comparisons between the alternatives, detailed investigation into throughput capabilities for each alternative, and a review of operational limitations for each alternative. If it is apparent that the confirmatory investigations contradict the results of this evaluation, a new evaluation should be held with potential title design re-scoping efforts to follow.

13. REFERENCES

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4. U.S. Department of Energy, Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities, DOE-STD-1020.

5. S. Walsh, Engineering Design File-1547 – SSSTF/ICDF Operational Scenario and Process Flows, EDF-1547, Rev. draft, October 2000.

6. U.S. Department of Energy Idaho Operations Office, Final Record of Decision, Idaho Nuclear Technology and Engineering Center, Operable Unit 3-13, Idaho National Engineering and Environmental Laboratory, DOE/ID-10660, Rev. 0, October 1999.

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8. EPA Solidification/Stabilization Use at Superfund sites, Office of Solid Waste and Emergency Response, United States Environmental Protection Agency, EPA-542-R-00-010, September 2000, www.epa.gov.

9. U.S. Environmental Protection Agency Stabilization/Solidification Processes for Mixed Waste, EPA 401-R-96-014. Office of Environmental Restoration, U.S. Department of Energy, Germantown, MD, June 1996.

10. Conner, J. R., Chemical Fixation and Solidification of Hazardous Wastes, Van Nostrand Reinhold, New York, 1990.

11. DOE-HDBK-3010-94, December 1994, "Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities," Page 5-7.

Appendix A

Waste Information

Waste Estimates For EDF Consistency

Overall Volume Estimates

SOLID

Total non-Liquid Waste Volume (yd^3) =	**483,800**
Stabilization non-Liquid Waste Volume (yd^3) =	35,765
Landfill non-Liquid Waste Volume (yd^3) =	448,035

LIQUID

Total Purge Water Volume (Gal) =	**262,450**

Non-Liquid Stabilization Matrix

WAG	Release Site	Volume (yd^3)	Matrices	Site Description	Reference
5	ARA-12	1,966	Sandy silty clay with rock pieces.	Unlined surface impoundment (370'x150'). Natural depression used to dispose of low-level waste and facility runoff.	Creg Bean (Geotec. Engineer 6-9941), WAG 5 ROD pp 59-63
10	Borax-01	11,110	Significant imported gravel in an area of silty clay soil	Site of leach pond for the boiling water reactor experiment (BORAX). Dimensions: 20' x 90'. Feed included: low-level rad liquid, non-rad cooling tower, H2SO4, NaOH, HBO2	Creg Bean (Geotec. Engineer 6-9941), WAG 10 Track 1 sites. Decision Doc package. DOC ID 5757 pp1-5
4	CFA-04	800	Rocky soil with a small percentage of calcine.	Shallow unlined surface depression (500'x150'). Basalt outcrops are present. Primary discharged: 100 yd^3 Hg contaminated calcine & liquid effluent from calcine laboratory	Debbie Wiggins (WAG 4 Project Engineer 6-9989); WAG 4 ROD pp.8-1 to 8-5
3	CPP-92	1,197	Soil (10%> 75"), (.75"<40%>.25"), (.25"<40%> 75μm), (10%< 75μm)	584 (2'x4'x8') boxes + 5 (4'x4'x8')boxes [Assumption: Boxes are 85% full]	Creg Bean (Geotec. Engineer 6-9941) ; IWTS
		4	Metal	1 (4'x4'x8')box [Assumption: Box is 60% full]	Creg Bean (Geotec. Engineer 6-9941) ; IWTS
		116	Concrete	40 (4'x4'x8')boxes [Assumption. Boxes are 60% full]	Creg Bean (Geotec. Engineer 6-9941) ; IWTS
		53	Soil/Asphalt/Concrete	18 (4'x4'x8')boxes [Assumption Boxes are 60% full]	Creg Bean (Geotec. Engineer 6-9941) ; IWTS
3	CPP-98	30	Soil (10%> 75"), (.75"<40%>.25"), (.25"<40%> 75μm), (10%<.75μm)	17 (2'x4'x8') boxes [Assumption. Boxes are 85% full]	Creg Bean (Geotec. Engineer 6-9941) ; IWTS
		209	Wood / Nails / Bolts	98 (4'x4'x8')box [Assumption. Box is 45% full]	Creg Bean (Geotec. Engineer 6-9941) ; IWTS
		7	Metal	2 (4'x4'x8')boxes [Assumption: Boxes are 60% full]	Creg Bean (Geotec. Engineer 6-9941) ; IWTS
		4	Undetermined	1 (4'x4'x8')boxes [Assumption Boxes are 60% full]	Creg Bean (Geotec. Engineer 6-9941) ; IWTS
3	CPP-99	30	Soil (10%> 75"), (.75"<40%>.25"), (.25"<40%> 75μm), (10%< 75μm)	15 (2'x4'x8') boxes [Assumption Boxes are 85% full]	Creg Bean (Geotec. Engineer 6-9941) ; IWTS
		2	Wood / Nails / Bolts	1 (4'x4'x8')box [Assumption: Box is 45% full]	Creg Bean (Geotec. Engineer 6-9941) ; IWTS
		11	Metal	5 (4'x4'x8')boxes [Assumption. Boxes are 45% full]	Creg Bean (Geotec. Engineer 6-9941) ; IWTS
		62	Concrete	29 (4'x4'x8')boxes [Assumption Boxes are 45% full]	Creg Bean (Geotec. Engineer 6-9941) ; IWTS
		12	Soil/Asphalt/Concrete	5 (4'x4'x8')boxes [Assumption Boxes are 50% full]	Creg Bean (Geotec. Engineer 6-9941) ; IWTS
		9	Undetermined	4 (4'x4'x8')boxes [Assumption. Boxes are 50% full]	Creg Bean (Geotec. Engineer 6-9941) ; IWTS
D&D&D		56	Rubble (concrete, metal, building materials)	Mixed Low-Level Waste (MLLW)	CWID document DOE/ID 10803 pp4-3 to 4-8
		16		Hazardous Waste (HW)	
1	TSF-07	1	PPE		
1	WRRTF-01	20,070	Silty clay	Four burn pits used for open burning of construction debris. Total Dimensions: 400' x 165'. Covered with 1/2 to 9 feet of clean soil.	Creg Bean (Geotec. Engineer 6-9941) ; WAG 1 ROD pp 9-1 to 9-8 section II

Total Volume (Yd^3)= 35,765

Liquid Purge Water Matrix

Group	Activity	Line Item From SOW	Schedule	Best Estimate Gallons	Comments
4	Drilling Phase I Wells	40290	10/31/00 to 3/07/01	5,780	Estimate of water to be decanted off of drill cuttings frac tank. 14 perched water wells, 1 aquifer well
4	Sampling Phase I Wells	40310	3/08/01 to 4/06/01	1,500	Estimate based upon existing standing water in perched water wells, no contribution from new lysimeters
4	Tracer Test	40340	3/29/01 to 9/19/01	250	Assumes use of carbon samplers and no purging of wells for sampling. Test plan in preparation and may change.
4	Drilling Phase II Wells	40560	7/24/02 to 2/21/03	7,800	4 perched water wells, 2 aquifer wells
4	Sampling Year 1	40580	4/25/03 to 8/13/03	2,900	estimate based on existing perched water wells, plus 300 gall/well for new aquifer wells (skimmer wells)
4	Sampling Year 2	40640	10/02/03 to 09/03/04	2,900	
4	Sampling Year 3	40690	10/04/04 to 09/30/05	2,900	
4	Sampling Year 4	40740	10/04/05 to 09/29/06	2,900	
4	Sampling Year 5	40790	10/03/06 to 09/28/07	2,900	
5	INTEC Baseline GW Sampling	50280	10/11/00 to 11/21/00	42,300	Initial sampling 47 wells, estimate 900 gall/well
5	Micropurge Sampling	50300	11/22/00 to 01/19/01	2,100	Sampling 21 wells, estimate 100 gall/well
5	Facility Monitoring Year 1	50430	05/25/01 to 06/26/01	21,000	Sampling 21 wells, estimate 1,000 gall/well, estimated minimum based on micropurging
5	Facility Monitoring Year 2	50430	5/22/02 to 6/21/02	21,000	Sampling 21 wells, estimate 1,000 gall/well, estimated minimum based on micropurging
5	Facility Monitoring Year 3	50430	5/20/03 to 6/19/03	21,000	Sampling 21 wells, estimate 1,000 gall/well, estimated minimum based on micropurging
5	Facility Monitoring Year 4	50430	5/20/04 to 6/19/04	21,000	Sampling 21 wells, estimate 1,000 gall/well, estimated minimum based on micropurging
5	Facility Monitoring Year 5	50430	5/20/05 to 6/19/05	21,000	Sampling 21 wells, estimate 1,000 gall/well, estimated minimum based on micropurging
5	Drilling Grp 5 Wells	50730	5/30/01 to 8/30/01	35,000	Estimate 5 aquifer wells, 2000 gall/well drilling, 5,000 gall/well if well development required
5	Vertical Profile Sampling	50750	10/03/01 to 10/23/01	7,900	Assume sampling 7 wells, 10 zones in each well, each zone 10 ft long by 8 inch diameter
5	24-hr Pumping/Statistic Sampling	50780	01/25/02 to 2/11/02	4,320	Assume sampling 6 zones, pumping each zone 24-hr at 0.5 gpm, 720 gall purged per zone
ICDF	Groundwater Monitoring	NA	NA	0	Assume ICDF monitoring will be initiated at time ICDF becomes operational. Should not impact SSSTF
OU3-14	Well Drilling	NA	01/01/01 to 03/01/01	21,000	Assume 3 aquifer wells drilled 1st quarter 2001 per TJ Meyer. Estimate 2000 gall/well drilling/ 5000 gall/well development
OU3-14	Groundwater Sampling Yr 1	NA	03/02/01 to 03/30/01	3,000	Sampling 3 wells, 1000 gall/well, Estimate annual sampling, minimum based on micropurge
OU3-14	Groundwater Sampling Yr 2	NA	03/02/02 to 03/30/02	3,000	Sampling 3 wells, 1000 gall/well
OU3-14	Groundwater Sampling Yr 3	NA	03/02/03 to 03/30/03	3,000	Sampling 3 wells, 1000 gall/well
OU3-14	Groundwater Sampling Yr 4	NA	03/02/04 to 03/30/04	3,000	Sampling 3 wells, 1000 gall/well
OU3-14	Groundwater Sampling Yr 5	NA	03/02/05 to 03/30/05	3,000	Sampling 3 wells, 1000 gall/well

Total Volume (Gal)= 262,450